



Managing Cover Crops and Green Manures

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Insufficient Residue = Soil Crusts



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- When rain drops impact on bare soil, they disrupt aggregates and cause seals and crusts to develop that reduce water infiltration and interfere with crop growth.
 - Residue cover reduces this damage. Cover crops can contribute to increased residue cover. Benefits are greatest when cover crops are combined with no-till management.
 - photo credit: Seth Dabney
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Cover crops

■ Advantages

- increase residue cover
- recycle nutrients
- increase soil carbon
- legumes fix nitrogen
- weed control
- increase mycorrhizal infection of crops for enhanced water and nutrient uptake

■ Disadvantages

- must be planted when time is limited
- additional costs (planting and killing)
- reduce soil moisture
- increase pests and diseases
- allelopathy

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- There are both advantages and disadvantages to using cover crops.
 - The fact that cover crops are not grown by most farmers suggests that they perceive that the disadvantages outweigh the advantages.
 - Research should be focused to develop systems to reduce the disadvantages and enhance the advantages.
 - reducing costs of planting and killing cover crops
 - using cover crops to assist in weed control (a good cover crop should suppress hard to control weeds but itself be easy to control)
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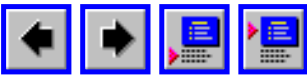


Residue effects on crops

- Beneficial
 - prevent surface sealing
 - cooler soil temperature
 - moister near-surface soil
 - higher biological activity

- Cover Crops increase residue cover in no-till systems

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- Crop and cover crop residues have several beneficial effects in addition to erosion control.
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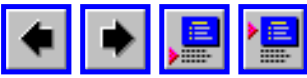
Plowing cover crops into soil does not increase soil organic matter

■ Tillage

- burns up soil organic matter
- starves soil organisms
 - ◆ fungi
 - ◆ worms
 - ◆ ants
 - ◆ beetles

■ Tillage controls weeds

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- When cover crops are tilled into the soil, they decompose rapidly, primarily through bacterial activity.
 - When cover crops are left on the surface, they provide a continuing food source for a range of soil micro- and meso-fauna that will starve if all residues are tilled into the soil.
 - Organic matter buildup in undisturbed grasslands and forests proves that tillage is not needed to mix organic matter into the soil, a common misconception.
 - Tillage does control weeds and can temporarily remedy compaction. These are the main reasons to consider tilling soil. Tillage does not increase soil organic matter. In fact, it always decreases soil organic matter.
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No-till

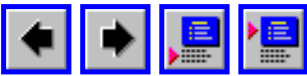
■ Advantages

- reduced labor
- reduced equipment cost
- increased field access
- reduced sand blowing
- reduced erosion

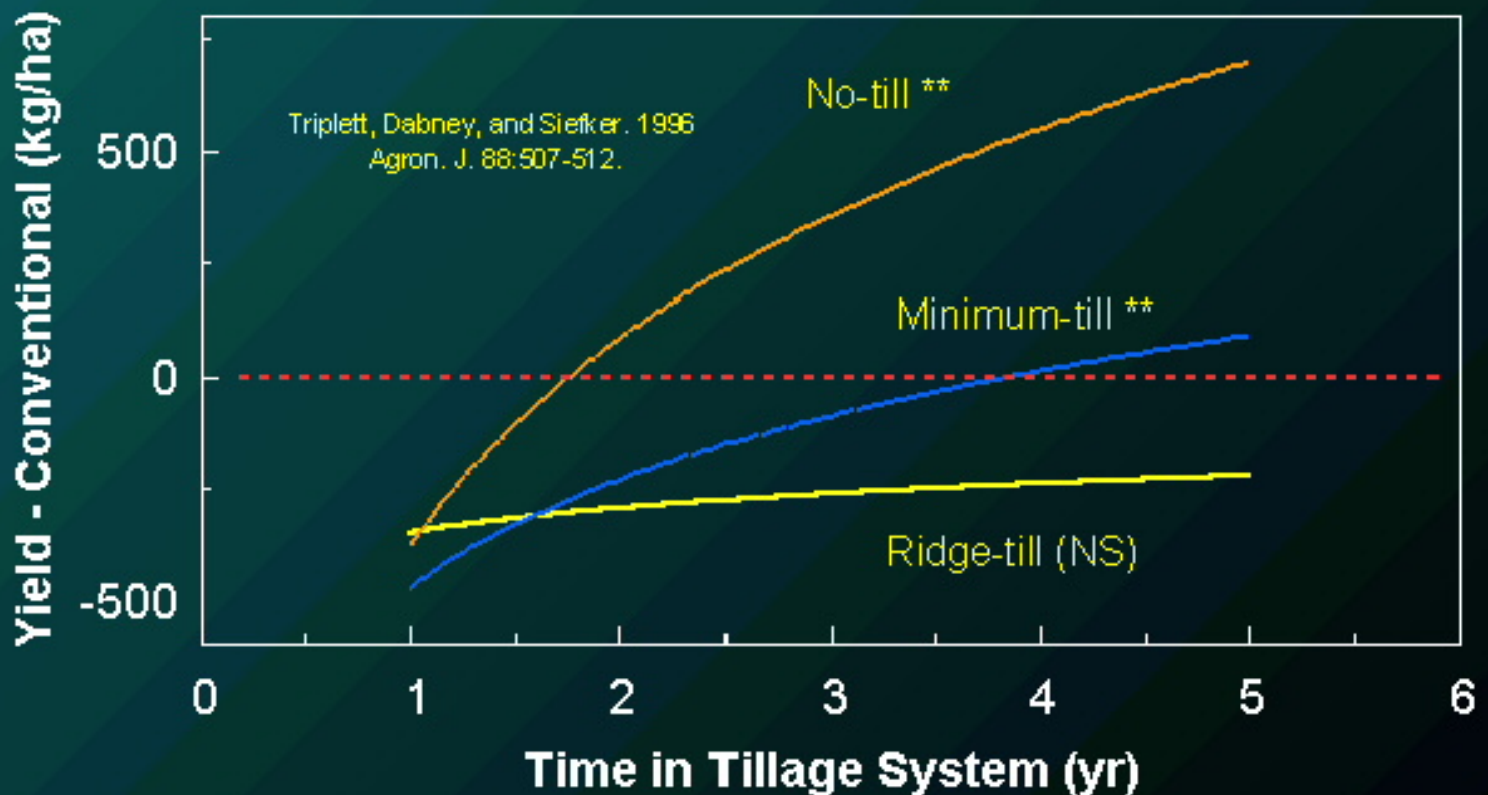
■ Disadvantages

- greater herbicide use
- specialized planting equipment needed
- soil compaction
- learning curve

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- There are advantages and disadvantages to no-till.
 - The main reason for the rapid adoption being observed this year are economic (labor and machinery savings) combined with the ability of farmers to control weeds with new technology.
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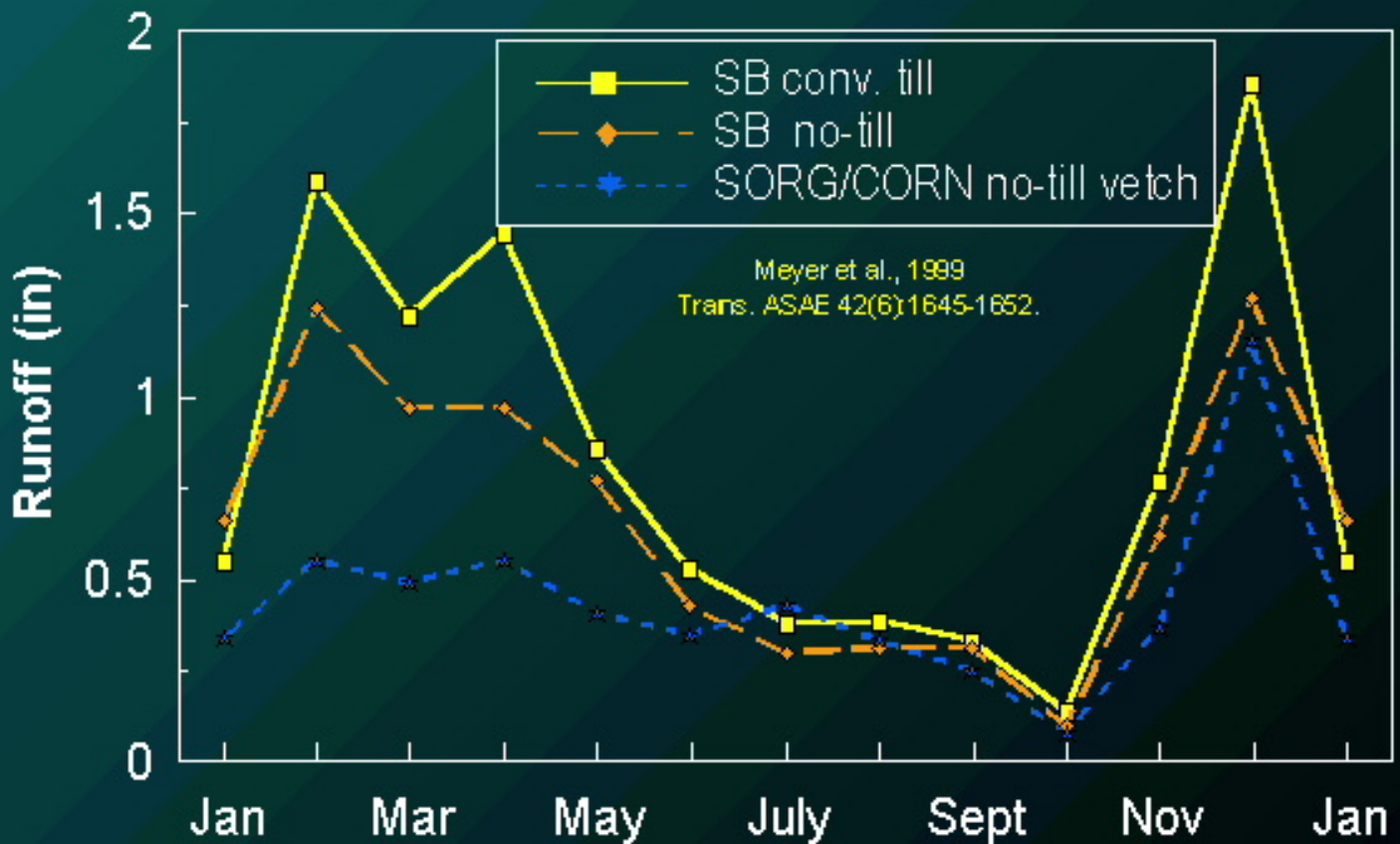


Cotton Yields Increased with Time in No-till



- Cotton yield of four tillage systems minus the yield of the conventional (chisel plow/disk/hip) system show that relative productivity of no-till increased over time on a silt loam soil.
- This was due to improve no-till know-how and techniques as much as improvements in soil properties. With good know-how, no-till yields can be as good as conventional in the first year.

Average Monthly Runoff (1990-95)



- No-till reduced runoff, particularly in the winter months.
- Changing from soybean to a higher-residue crop (corn or sorghum) and adding a winter cover crop had even greater effects on reducing runoff from a silt loam soil on 5% slope. Part of this was water use by the cover crop drying out the soil, making more room for rainfall to infiltrate.

Rather than burning residues, in Paraguay, additional cover crop residues are needed to make no-till successful

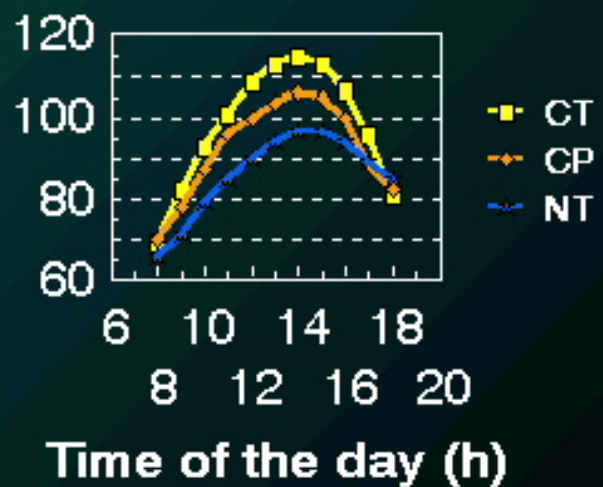


- This field, however, shows a black oat (*Avena strigosa*) cover crop that has been killed (without herbicides) using a roll-chopper (see later).
- Rolph Derpsch (left) has developed no-till systems in South America for areas between 23 and 28 degrees latitude (slightly warmer than Mississippi, which is about 30 to 35 degrees latitude). No-till adoption has reached 95% of cropland in the region where he works.
- Cover crops are a key component of successful no-till systems in warm areas because of their ability to suppress weeds that cannot be economically controlled by chemicals.
- Any time that a crop will not be growing for 6 weeks, Derpsch recommends that a cover crop be planted.
- photo credit: Seth Dabney

Soil temperature fluctuations are reduced as residue cover increases

- Lower maximum temperatures improve crop growth in hot areas

Soil temperature (°F) at 1"
Londrina, Brazil (23°S)

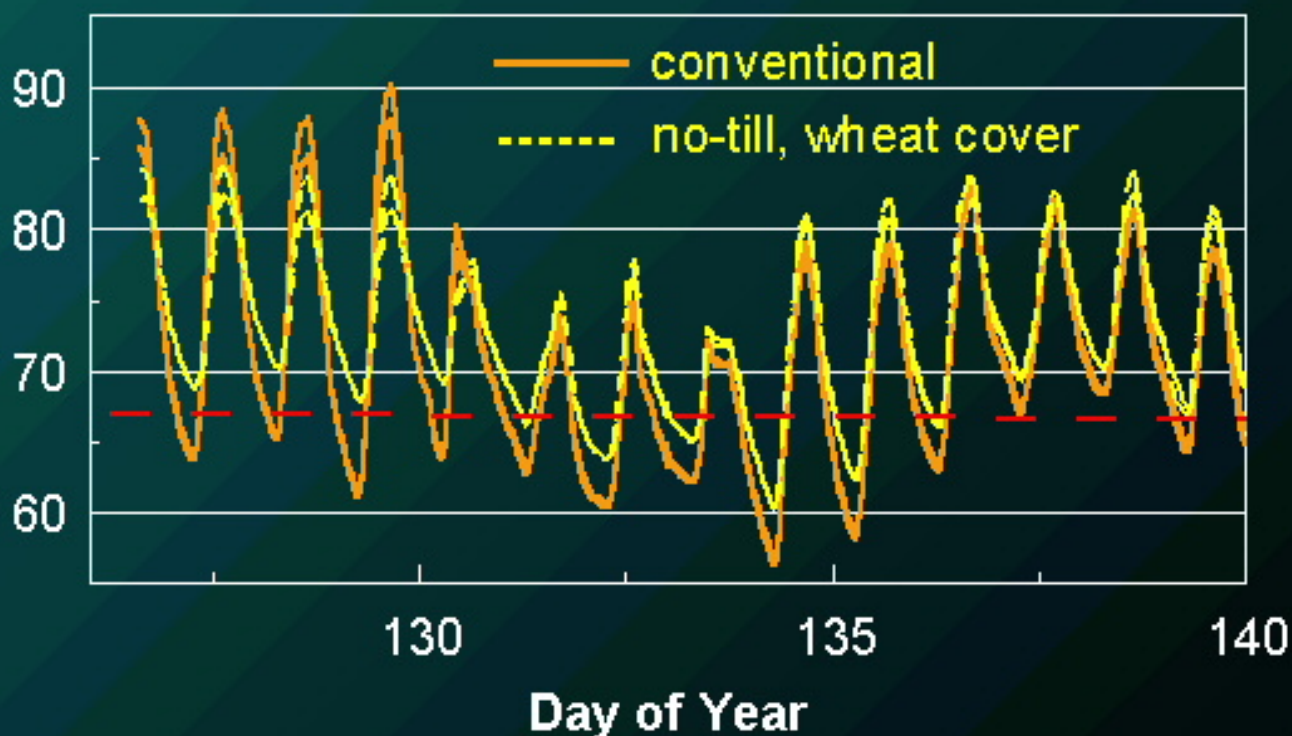


Derpsch et al. 1996

- Derpsch showed that one reason for improved growth of no-till crops in his climate was cooler soil temperature.

Soil temperatures at 8:00 AM are usually warmer under a cover crop

Degrees F



- While it is commonly said that soil temperatures are warmer under conventional tillage and cover crops keep the soil cooler, reality is not really that simple.
- In Mississippi, the extension service recommends that cotton planting be delayed until soil temperature at 8:00 AM is at least 68 degrees F and there is a favorable 5-day forecast. 8:00 AM is close to time when soil temperature at planting depth is at a daily minimum temperature.
- The data shows that in early May in northern Mississippi, soil temperature was warmer during the afternoon with conventional tillage than with no-till and a cover crop, but at night and at 8:00 AM was warmer with no-till and a cover crop than with conventional tillage. The cover crop mulch was like a blanket, keeping the soil cooler in the afternoon but warmer at night. Which makes crops grow better, warmer afternoon temperature or warmer nights? (The answer probably depends on the crop).
- Note also that when a cold snap occurred, and the soil started to cool from day to day (days 130 to 135), the soil was actually warmer both daytime and nighttime with no-till

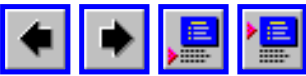
and a cover crop.

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Reseeding Legume Cover Crops like Spotted Burclover increase soil cover contribute N fertility



- Reseeding winter legume cover crops can establish themselves from volunteer seed. They generally produce earlier and denser stands than planted cover crops because they can start growing in the fall as soon as moisture conditions are favorable and more seed is available. Hard seed enables these cover crops to grow back for several years from a single seed crop.
- Shown here, southern spotted burclover (really an annual medic (*Medicago arabica*)) is an excellent reseeding winter legume cover crop. After hairy vetch, it was the most common legume cover crop in the Mississippi Delta during the 1950's.
- Today there are no commercial seed sources even though there used to be several named cultivars. These have been lost since cover crops stopped being commonly grown. Because it is well adapted to the region, spotted burclover can be found in volunteer stands along field borders and roads throughout the Delta from January through March.
- photo credit: Seth Dabney



Reseeding Legume Cover Crop

- Selection criteria
 - N accumulation
 - Earliness
 - Winter vigor and hardiness
 - hard seededness
(volunteer back for several years from one seed crop)
- Best choice: balansa clover

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- We screened a variety of legume for use as cover crops over a 20 year period.
 - The two best were the Southern spotted burclover and balansa clover (*Trifolium michelianum*). Of these, only balansa clover is currently commercially available.
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Tiptonville, TN

6B



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- Here 'Paradana' balansa clover is shown blooming earlier than crimson clover in northwestern Tennessee.
 - photo credit: Seth Dabney
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Cover Crop Evaluation Sites

Mean Annual
Zone Minimum
°F

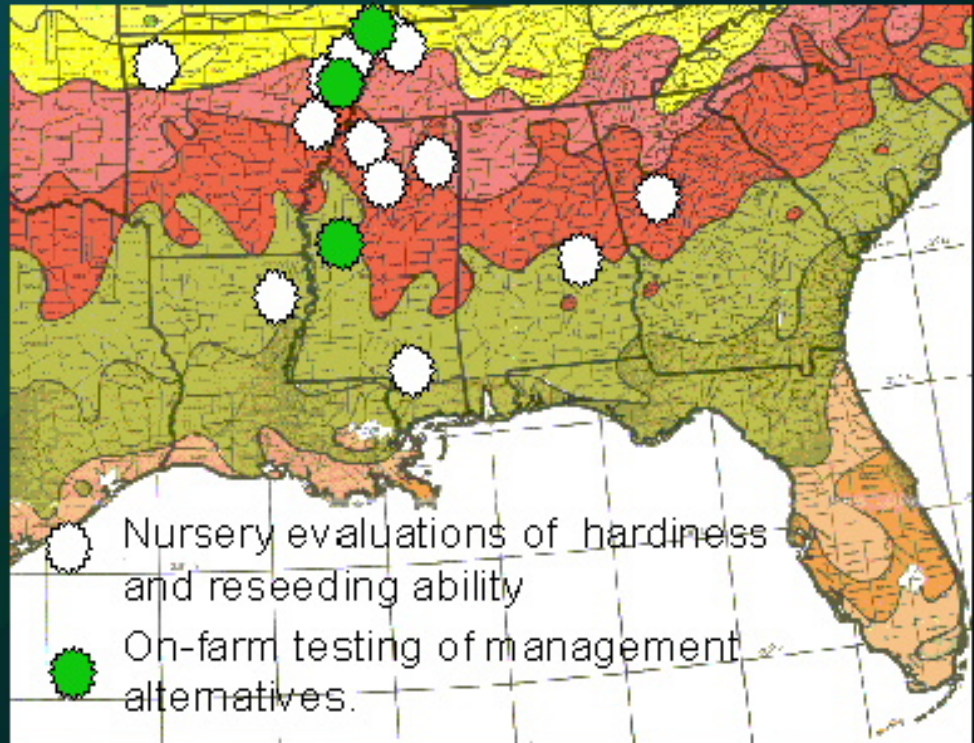
6B 0 to -5

7A 5 to 0

7B 10 to 5

8A 15 to 10

8B 20 to 15



- This indicates some of the locations where legume cover crop screening trials were conducted over a number of years during the 1990's.
- Results indicate balansa clover is hardy in areas colored pink, or warmer.

Mississippi County, AR

7A



- Here is balansa clover growing on a heavy soil in northeastern Arkansas.
- Clover was just starting to bloom on 1 April. Note growth was greater than of volunteer vegetation (weeds) in immediate background and was similar to that of a rye (*Secale cereale*) cover crop (further background).
- photo credit: Seth Dabney



Flowering or heading dates in northern Mississippi

Cover Crop	1991	1992	1993	1994
'Tibbee' Crimson	4/10	4/8	4/10	4/11
'Paradana' Balansa	3/27	3/30	4/1	3/26
Spotted Burdock	3/20	3/12 [†]	3/7	3/30
'Gulf' Annual Ryegrass	4/24	4/17	4/26	after 4/18
'Abruzzi' Rye			4/2	4/8
'Elbon' Rye			4/10	4/12
'Rymin' Rye			4/26	

[†] reseeded stand

- Two points to note:
 - 1) Balansa clover was somewhat earlier to start flowering than Tibbee crimson clover, which was used as a check in these trials. Balansa, however, flowers over a longer period than crimson clover. Maximum hard seed is probably not produced until 40 days after first bloom (early May at this site).
 - 2) Among rye cultivars, the southern types (Abruzzi and Elbon) flower much earlier than northern types. These southern types are preferred in mild areas where production of tall residue is desired prior to growth termination and planting of subsequent crops.

Moorhead, MS

8A

(Seeded)



- Balansa clover grew profusely during the mild winter of 1998-1999 in the Mississippi Delta. Growth was allowed to continue until May 10 in this 17 acre field in 1999. Killing the cover crop at the growth stage shown would maximize N availability to the subsequent crop. By allowing it to grow longer, N is transferred into the seed so less is available in the seed production year.
- photo credit: USDA-ARS

Moorhead, MS

8A

(volunteer)



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- This was the volunteer stand on the same field the following February (2000).
 - This cover crop was not planted, but came back from seed produced the year before after rows were hipped in the fall. This cover crop had 70 lbs N/acre in the aboveground biomass when it was killed soon after this photo was taken in preparation for planting a corn crop.
 - Here an entomologist is checking the clover for the presence of insects.
 - photo credit: Seth Dabney
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Conclusions

- Reseeding cover crops are promising
 - planting may need to be delayed in first seed production year

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- The biggest cost of reseeding legume cover crops is not the seed cost, but the opportunity cost associated with delaying termination of the cover crop until hard seed has been produced. By growing until early May, the cover crop can dry out the soil and delay planting of subsequent crops past their optimum sowing times. Irrigation can reduce part of this risk.
 - For long term volunteer balansa clover cover crops, a farmers must to find a crop rotation that allows the cover crop to grow until early May about one year in four in order to maintain a seed bank. An earlier maturing cover crop would reduce the opportunity cost.
-

Sunn Hemp - Rapid Legume Growth Following Corn Killed by Frost



- Another approach is planting rapidly growing legume cover crops in the fall.
- This is sunn hemp (*Crotalaria juncea*) planted after a corn crop in southern Alabama.
- This tropical legume produced a great deal of growth and fixed considerable N in just 6 weeks. It grows until it is killed by frost. It does not produce viable seed in Alabama.
- For more information, contact Wayne Reeves, Auburn, AL.
- photo credit: Seth Dabney



Killing Cover Crops Without Tillage

- Mowing
- Rolling (roll chopping)
- Transplant directly into residues

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- Tall dense cover crops can be expensive to kill with herbicides or tillage. Two promising alternatives are mowing and rolling.
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Commercial Roller in Brazil



- Rolling choppers have been commercially produced for cover crop management in South America.
- photo credit: Seth Dabney

Even Tall Cover Crops Can be Killed by Rolling



- Cover crop height is not a limitation to the effectiveness of rolling choppers, as it may be for herbicide application.
- In fact, roll chopping works best if cover crops are at least two feet tall.
- photo credit: Seth Dabney

Commercial Roller in Brazil



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- Some rolling choppers are designed with replaceable blades.
 - photo credit: Seth Dabney
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Horse-drawn Roller in South America



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- Rolling choppers can be adapted to a variety of farming scales.
 - This draft-animal powered devise was being used in Paraguay.
 - photo credit: Seth Dabney
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Rolling a Black Oat Cover Crop in South America



- Here a rolling chopper is being used to terminate a black oat cover crop.
- photo credit: Plantio Direto

Homemade Roller in Ohio



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- This rolling chopper was built by researchers in Ohio.
 - photo credit: Nancy Creamer
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Do-all Roll Chopping Rye/Vetch



- The cotton stalk chopper that is the front end of a "do-all" was used to control a rye/vetch cover crop in a trial in Braggadocio, MO.
- photo credit: Seth Dabney

Do-all Roll Chopper



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- Although the rolling basket was open, it did not choke up in this trial.
 - photo credit: Seth Dabney
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Do-all Rolled Rye/Vetch



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- The rolling stalk chopper knives cut the stems, particularly on the top of beds, and left the residues on the soil surface.
 - photo credit: Seth Dabney
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Wayne Reeves: Re-bar Roller



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- Wayne Reeves has found that just crushing the stems with rods can kill some cover crops as effectively as cutting the stems with knives.
 - photo credit: Seth Dabney
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Wayne Reeves: Re-bar Roller Behind Paratill Subsoiler



- His roller is mounted behind a Paratill subsoiler that he pulls through cover crops in the spring.
- On coastal plain soils, annual deep tillage is needed to break up naturally occurring hardpans. Spring subsoiling can leave the soil with too much pore space, causing it to dry out. By following the subsoiler with the roller, the soil is both loosened and firmed. The cover crop helps dry the soil making the subsoiling action more effective. Adding re-bars to the roller allows the operation to kill the cover crop. Thus, the cover crop is killed and the soil is put into condition for planting in a single operation.
- photo credit: Seth Dabney

In Maryland, tomatoes transplanted into rolled hairy vetch have been more profitable than in a black plastic mulch system.



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- Researchers have shown that vegetables can be transplanted directly into roll-killed cover crops.
 - Here a hairy vetch mulch produced tomatoes more economically than black plastic mulch.
 - photo credit: USDA-ARS
-

Broccoli being transplanted into rolled summer cover crops in Virginia



- Researchers in Virginia have reported that broccoli transplanted into roll-killed summer cover crops can be productive with no herbicide applications.
- photo credit: Ron Morse

One month after rolling rye, weeds beginning to break through.
Weed control will be the biggest challenge with organic no-till.



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- Rolled cover crops do not provide as high a level of weed suppression as do cover crops that are still growing.
 - As shown here, weeds will eventually come through. Here they are appearing 4 weeks after a rye cover crop was killed and rolled.
 - Heavy cover crop residues could interfere with some subsequent non-herbicidal weed control options like hoeing, flaming, or cultivation.
 - photo credit: Seth Dabney
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Detrimental Effects of Residues on direct-seeded crops

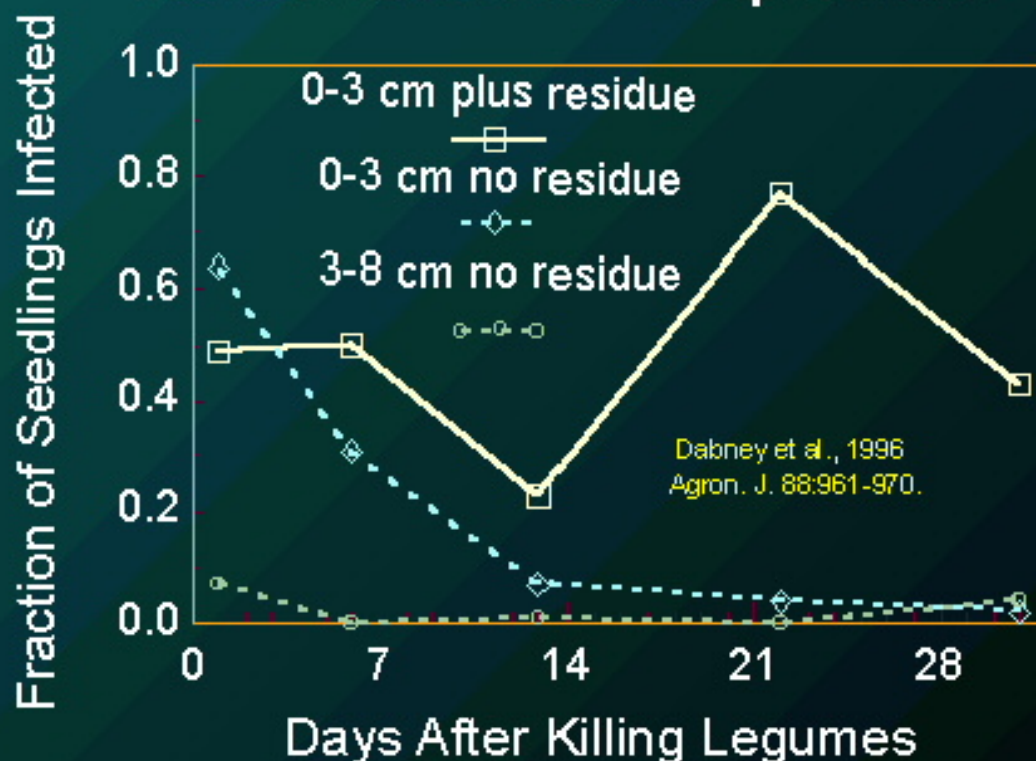
- interference with seed placement
- reduced light availability
- colder soil temperature
- wetter near-surface soil
- immobilization of nutrients by microbes
- higher population of pathogens and insects
- allelochemicals

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- While residues have advantages discuss up to know, very heavy levels of mulch can have negative impacts as well.
 - These effects need to be recognized and avoided.
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Disease can be worse following legume cover crops

Rhizoctonia infection of sorghum seedlings grown in soil with and without cover crop residues



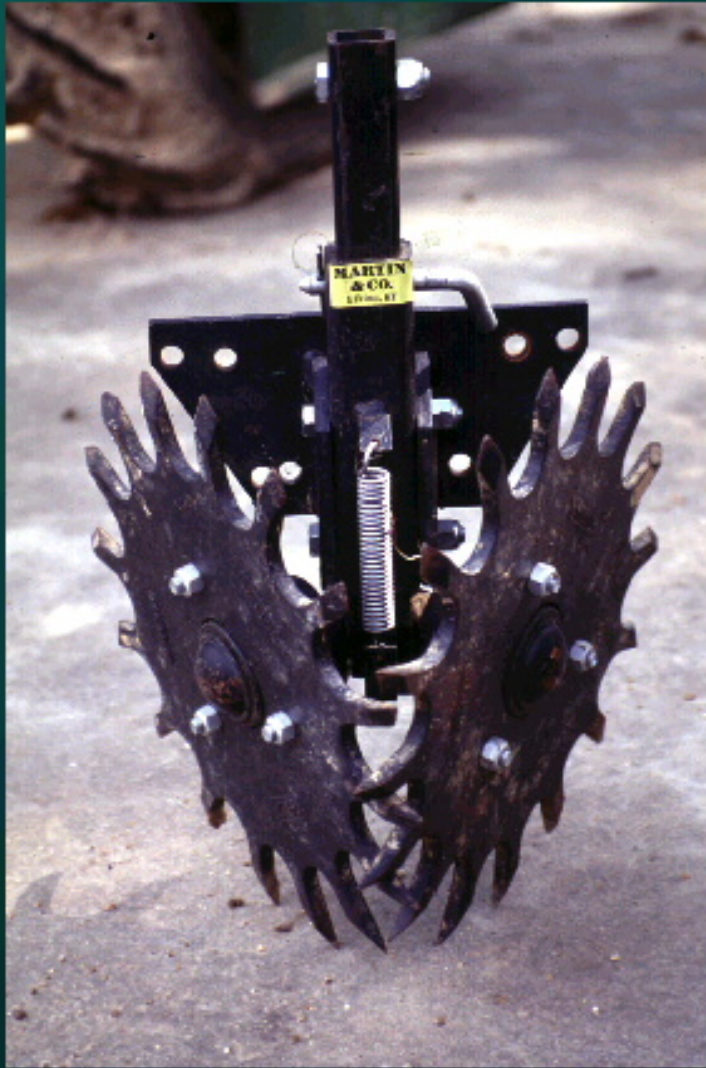
- When residues come in contact with the seed or the seedling, the chances for seedling disease are increased during the first two or three weeks after cover crop killing.
- This problem is greater with legume cover crops than with cereal cover crops.
- The microorganisms that are decomposing the tender cover crop produce enzymes that can also digest the tender seedlings. This increased microbial activity is sometimes referred to as a "heat" even if the temperature does not rise appreciably.

Row Cleaners can Clear Heavy Residues Outside of Single Depth Bands, improving stands of direct seeded crops



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- When attempting to direct seed into heavy cover crop residues, chances of success can be improved by using row cleaners that move some of the residues away from the planted row.
 - photo credit: Seth Dabney
-

Row Cleaner Planter Attachment



- This is an example of a planter mounted row cleaner that can effectively move residues away from the planting zone and prevent "hair-pinning" of residues into the seeded zone.
- photo credit: Seth Dabney

row cleaner

coulter



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- Studies compared row cleaners with coulters on a no-till planter.
 - photo credit: Seth Dabney
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row cleaner

coulter

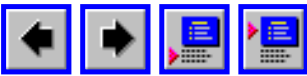


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- Cotton stands were improved by row cleaners when no-till planting less than three weeks after killing cover crops.
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Row Cleaners Will Plug if Residues are Green and Tough



- A word of caution...
 - row cleaners will plug up if cover crop residues are not dry and brittle at planting time.



How long should I delay planting after killing cover crops?

- Factors to consider
 - crop to be planted
 - cover crop biomass
 - soil moisture
 - temperature
 - planting equipment
- It is safest to wait 3 to 4 weeks after killing to plant
- Tined-wheeled row cleaners may allow planting as soon as residues are dry and brittle

-
- Cover crop termination decisions should consider a balance between many factors
 - nitrogen accumulation
 - weed control
 - water availability
 - cover crop seed production
 - Waiting 3 to 4 weeks minimized disease problems and improves chances for good soil moisture in the top two inches of the soil.
 - Where irrigation is available, row cleaners can allow successful planting as little as 2 to 5 days after killing a cover crop.
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mycorrhiza



Ernie Flint -

Enhanced early growth in no-till cotton following a wheat cover crop was associated with increased and earlier infection with beneficial mycorrhizal fungi.

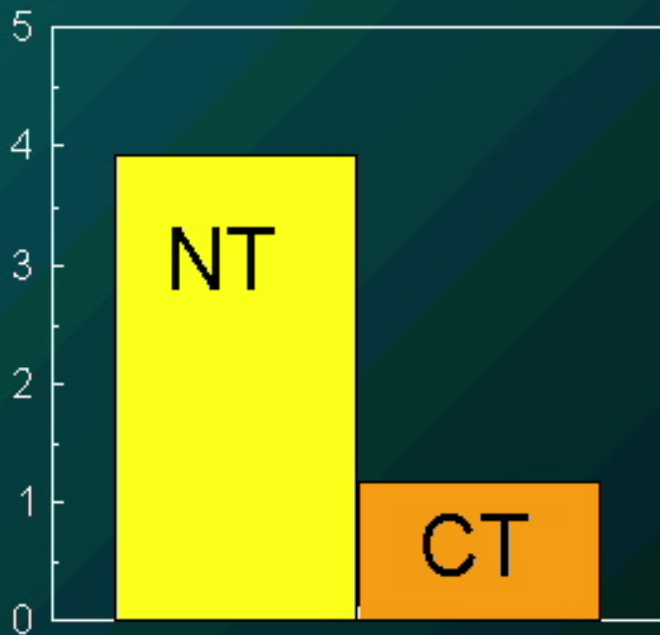
- A final aspect of cover crop impacts that most people don't recognize is their role in supporting beneficial mycorrhizal fungi.
- Ernie Flint observed enhanced early growth of no-till cotton planted into a wheat cover crop compared to conventional till cotton with no cover crop. He tried to find how why?
- In one experiment he used a plug cutter to move plants from one environment to the other.
- photo credit: Seth Dabney



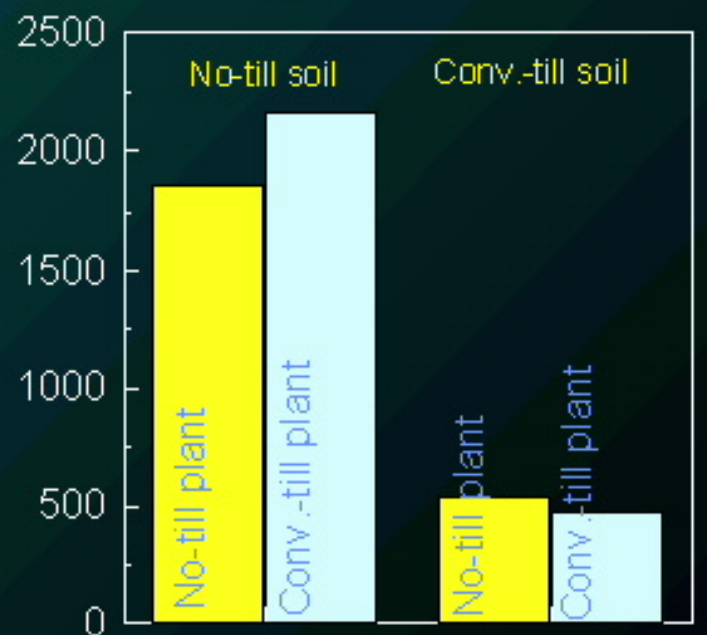
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- He put no-till plants into a conventional till plot, and vice-versa.
 - photo credit: Seth Dabney
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Cotton infection with mycorrhiza higher with no-till and wheat cover crop

mycorrhizal infection per cm root



mycorrhizal hyphal counts per mm²



- Results showed that no-till cotton was indeed colonized more rapidly with mycorrhiza than conventional till cotton.
- However, when plants were transplanted, the effect was found to follow not with the plant, but the environment surrounding the plant.
- The interpretation is that the hyphal network supported on the roots of the cover crop remained intact when the soil was not tilled. The hyphae were then able to infect the seedling cotton root, enhancing early-season uptake of water and nutrients and providing greater resistance to environmental stress to the no-till seedling.
- A related observation... When, at the end of a ten-year experiment, some reps of a cover crop were killed in February and others at the usual time in April, and cotton was planted on plots in early May, the normally observed enhanced early growth of no-till cotton was not observed in the February-killed plots. Perhaps the mycorrhizal network starved following the early cover crop killing date. This may be an unexpected side effect of the frequently-observed practice of killing winter vegetation in late winter to avoid

reproduction of certain insect pests.

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Suggestions - Cover Crops

- Let cover crops grow longer than is commonly done (if water is available)
 - increased residue can be managed
 - increased residue conserves water later
 - maintains mycorrhiza hyphae network for early growth boost
- Do not till unless needlessly
 - it is like taking money out of the bank!

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- This summarizes my recommendations.
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Questions?



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